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Tetsuzo Ueda

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02/22/2005

EXAMINER

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Washington, DC 20005-3096

ART UNIT

PAPER NUMBER

1765

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/904,129

Applicant(s)

UEDA, TETSUZO

Examiner

Matthew J Song

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~ The MAILING DATE of this communication appears on the cover sheet with the correspondence address ~
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
 - If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
 - If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
 - Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 December 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 16, 17, 19-35, 37-43, 48 and 51-55 is/are pending in the application.
- 4a) Of the above claim(s) 21, 22 and 26-30 is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 16, 17, 19, 20, 23-25, 31-35, 37-43, 48 and 51-55 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

DETAILED ACTION

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 12/2/2004 has been entered.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claim 16 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 16 recites, "lattice constant of the initial buffer layer is between that of the substrate and that of the overgrown III-V alloy film" in the last two lines. The instant specification does not support this limitation. The instant specification does not any relationship between the lattice constant of the initial buffer layer and the lattice constant of the substrate and nitride alloy. The instant specification do not provide support for the scope of claim 16 further limit the claim by specifying a relationship of lattice constants.

4. Claim 54 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claim 54 recites an initial buffer layer of SiC on a silicon substrate and Claim 54 depends from claim 16, which recites, "lattice constant of the initial buffer layer is between that of the substrate and that of the overgrown III-V alloy film". The lattice constant of silicon is approximately 5.43 angstroms (Ciszek US 5,785,769), SiC is 3.08 and GaN is 3.189 (pg 10 of the instant specification). The lattice constants of the materials do not meet the claimed relationship limitations required by claim 16.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

6. Claims 16, 17, 19, 24, 31, 32, 52 and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kawazu et al (US 5,764,673) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675).

Kawazu et al teaches a method of forming a first buffer layer of SiC on a Si substrate and growing a second buffer layer comprising $\text{Al}_x\text{Ga}_{1-x}\text{N}$ on the first buffer layer and GaN series

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compound semiconductors are grown on the AlGaIn second buffer layer to improve crystalline quality of the GaN series compound semiconductor layers (col 3, ln 35-50). The first buffer layer on the Si substrate reads on applicants' initial buffer layer with a lattice constant between that of the substrate and that of the overgrown III-V alloy film. Kawazu et al also teaches using MOCVD to deposit the semiconductor layers and other methods may be employed (col 8, ln 10-30). Kawazu et al also teaches AlGaIn layer can be grown on a second buffer layer of GaN and the second buffer layer can be GaN, AlN or AlGaIn (col 6, ln 1-45 and col 8, ln 20-25). Kawazu et al also teaches a compound semiconductor material of $\text{Al}_x\text{Ga}_y\text{In}_z\text{N}$ ($0 \leq x, y, z \leq 1, x+y+z=1$) (col 1, ln 15-25). Kawazu et al does not explicitly teach using a buffer layer with group III elements different from any group III element in the grown III-V nitride alloy film. However, Kawazu et al teaches using a buffer layer of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ($0 < x < 1$) and a semiconductor layer of $\text{Al}_x\text{Ga}_y\text{In}_z\text{N}$ ($0 \leq x, y, z \leq 1, x+y+z=1$) (col 1, ln 15-25 and col 3, ln 35-50), which suggests that the fraction of any group III element for the buffer and nitride layer can be zero. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kawazu et al by selecting a buffer layer and a nitride alloy layer with different Group III elements because selection of a known material based on its suitability for its intended purpose is held to be obvious (MPEP 2144.07).

Kawazu et al does not teach spin coating the substrate with a liquid comprising one or more group III elements and nitride on a substrate and annealing the spin-coated layer in a gas atmosphere at a temperature equal to or higher than 700°C so as to crystallize the spin coated layer spreading a liquid comprising group III elements and nitrogen on a substrate and coating

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the substrate with a thin film comprising group III elements and nitrogen by spinning at selected rotation speeds.

In a method of forming gallium nitride, note entire reference, Puchinger et al teaches a chemical solution deposition method used to grow thin epitaxial GaN film on sapphire substrate. Puchinger et al teaches the film were grown by spin coating a gallium carbodiimide based polymeric precursor, this reads on applicant's liquid comprising group III elements and nitrogen, onto sapphire and pyrolyzing in NH_3 at 900°C (Abstract). Puchinger et al also teaches buffer layers or AlN or GaN were found to improve the crystal quality of deposited GaN films (pg 153-154). Puchinger et al also teaches the GaN films may be used as buffer layers in conventional GaN thin film growth techniques (pg 154). Puchinger et al teaches spinning speeds (table 1) and heat treating until transformation of a precursor material into a poly or single crystal thin film (pg 154), this reads on applicant's annealing so as to crystallize the spin coated layer. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kawazu et al with Puchinger method of making a buffer layer for GaN films using solution deposition because it is simpler than conventional techniques (pg 154).

In a method of producing GaN layers, Aldinger et al teaches a precursor compound is distributed uniformly over a substrate of Si, SiC or Al_2O_3 by spin coating and a pyrolysis treatment of the precursor compound is carried out by heating to a temperature of at least 600°C under a reactive atmosphere containing ammonia to convert the precursor into crystalline GaN (col 2, ln 1-65 and Claim 1). Aldinger et al teaches a precursor compound of $\text{Ga}_x(\text{NCN})_x(\text{SiMe}_3)_y\text{Cl}_z$ (col 4, ln 1-10), this reads on applicant's liquid comprising group III elements and nitrogen. The GaN layers can be used as buffer layers for production of thick GaN

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layers (col 3, ln 30-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kawazu et al with Aldinger et al's method of making a buffer layer for GaN because it is simpler and economically advantageous (col 1, ln 25-40).

7. Claims 16, 17, 19, 24, 31, 33, 52 and 55 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (EP 0999640 A2) in view Yuri et al (US 6,030,886) and further in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675).

Nakamura et al discloses a surface acoustic wave device comprising a sapphire single crystal substrate, a buffer layer of GaN formed on the sapphire single crystal substrate and an aluminum nitride single crystal layer formed on the buffer layer with an average thickness larger than that of the buffer layer (claim 1). Nakamura et al discloses a buffer layer of GaN and an AlN nitride alloy film, this reads on applicant's Group III elements are different. Nakamura et al also teaches the aluminum nitride single crystal layer is deposited by MOCVD ([0030]).

Nakamura et al does not teach an initial buffer layer.

Yuri et al teaches growth of GaN on a substrate using a ZnO buffer layer. Yuri et al also teaches a zinc oxide layer is sputtered onto a substrate of sapphire and zinc oxide layer is used to alleviate the lattice mismatching between sapphire and gallium nitride. Yuri et al also teaches forming a first gallium nitride layer at a lower temperature on the ZnO buffer layer (col 1, ln 10 to col 2, ln 50). ZnO has lattice constant between the lattice constant of sapphire and GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to

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modify Nakamura et al by using a substrate with a sapphire substrate with a ZnO buffer to alleviate lattice mismatching between the sapphire substrate and the nitride layer.

The combination of Nakamura et al and Yuri et al does not teach spin coating the substrate with a liquid comprising one or more group III elements and nitride on a substrate and annealing the spin-coated layer in a gas atmosphere at a temperature equal to or higher than 700°C so as to crystallize the spin coated layer spreading a liquid comprising group III elements and nitrogen on a substrate and coating the substrate with a thin film comprising group III elements and nitrogen by spinning at selected rotation speeds.

In a method of forming gallium nitride, note entire reference, Puchinger et al teaches a chemical solution deposition method used to grow thin epitaxial GaN film on sapphire substrate. Puchinger et al teaches the film were grown by spin coating a gallium carbodiimide based polymeric precursor, this reads on applicant's liquid comprising group III elements and nitrogen, onto sapphire and pyrolyzing in NH_3 at 900°C (Abstract). Puchinger et al also teaches buffer layers or AlN or GaN were found to improve the crystal quality of deposited GaN films (pg 153-154). Puchinger et al also teaches the GaN films may be used as buffer layers in conventional GaN thin film growth techniques (pg 154). Puchinger et al teaches spinning speeds (table 1) and heat treating until transformation of a precursor material into a poly or single crystal thin film (pg 154), this reads on applicant's annealing so as to crystallize the spin coated layer. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify combination of Nakamura et al and Yuri et al with Puchinger method of making a buffer layer for GaN films using solution deposition because it is simpler than conventional techniques (pg 154).

In a method of producing GaN layers, Aldinger et al teaches a precursor compound is distributed uniformly over a substrate of Si, SiC or Al_2O_3 by spin coating and a pyrolysis treatment of the precursor compound is carried out by heating to a temperature of at least 600°C under a reactive atmosphere containing ammonia to convert the precursor into crystalline GaN (col 2, ln 1-65 and Claim 1). Aldinger et al teaches a precursor compound of $\text{Ga}_w(\text{NCN})_x(\text{SiMe}_3)_y\text{Cl}_z$ (col 4, ln 1-10), this reads on applicant's liquid comprising group III elements and nitrogen. The GaN layers can be used as buffer layers for production of thick GaN layers (col 3, ln 30-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify combination of Nakamura et al and Yuri et al with Aldinger et al's method of making a buffer layer for GaN because it is simpler and economically advantageous (col 1, ln 25-40).

Referring to claim 55, the combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger teaches sputtering ZnO. The combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger does not teach RF sputtering. Sputtering ZnO is conventionally known in the art to be performed using RF sputtering, note Molnar (US 6,086,673) below. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger to RF sputter ZnO because it is conventional in the art.

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8. Claim 55 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (EP 0999640 A2) in view of Yuri et al (US 6,030,886) and further in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, 24 and 55 above, and further in view of Molnar (US 6,086,673).

The combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger teaches sputtering ZnO. The combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger does not teach RF sputtering.

In a method of forming a ZnO layer on a sapphire substrate, Molnar teaches ZNO sputtering deposition is performed on sapphire substrates in a conventional RF-diode sputtering machine (col 8, ln 15-30). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nakamura et al, Yuri et al and Aldinger et al or the combination of Nakamura et al, Yuri et al and Puchinger by using an RF sputtering, as taught by Molnar, because it is conventional method of sputtering ZnO.

9. Claims 16, 17, 19, 24 and 53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kato et al (US 6,423,984) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675).

Kato et al teaches a sapphire substrate is desirably treated by a nitriding treatment before forming a buffer layer to form a nitride film with thickness of 0-300 angstroms. Kato et al also teaches forming a buffer layer AlN having a thickness of 1.5 μm and a GaN layer formed on the buffer layer with a thickness of 2 μm (col 15, ln 1-67). Kato et al also teaches a buffer layer of

GaN (col 14, ln 60-67). Kato et al teaches a buffer layer of AlN and a layer of GaN, this reads on applicant's different Group III elements.

The Kato et al does not teach spin coating the substrate with a liquid comprising one or more group III elements and nitride on a substrate and annealing the spin-coated layer in a gas atmosphere at a temperature equal to or higher than 700°C so as to crystallize the spin coated layer spreading a liquid comprising group III elements and nitrogen on a substrate and coating the substrate with a thin film comprising group III elements and nitrogen by spinning at selected rotation speeds.

In a method of forming gallium nitride, note entire reference, Puchinger et al teaches a chemical solution deposition method used to grow thin epitaxial GaN film on sapphire substrate. Puchinger et al teaches the film were grown by spin coating a gallium carbodiimide based polymeric precursor, this reads on applicant's liquid comprising group III elements and nitrogen, onto sapphire and pyrolyzing in NH_3 at 900°C (Abstract). Puchinger et al also teaches buffer layers or AlN or GaN were found to improve the crystal quality of deposited GaN films (pg 153-154). Puchinger et al also teaches the GaN films may be used as buffer layers in conventional GaN thin film growth techniques (pg 154). Puchinger et al teaches spinning speeds (table 1) and heat treating until transformation of a precursor material into a poly or single crystal thin film (pg 154), this reads on applicant's annealing so as to crystallize the spin coated layer. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kato et al with Puchinger method of making a buffer layer for AlN or GaN films using solution deposition because it is simpler than conventional techniques (pg 154).

In a method of producing GaN layers, Aldinger et al teaches a precursor compound is distributed uniformly over a substrate of Si, SiC or Al_2O_3 by spin coating and a pyrolysis treatment of the precursor compound is carried out by heating to a temperature of at least 600°C under a reactive atmosphere containing ammonia to convert the precursor into crystalline GaN (col 2, ln 1-65 and Claim 1). Aldinger et al teaches a precursor compound of $\text{Ga}_w(\text{NCN})_x(\text{SiMe}_3)_y\text{Cl}_z$ (col 4, ln 1-10), this reads on applicant's liquid comprising group III elements and nitrogen. The GaN layers can be used as buffer layers for production of thick GaN layers (col 3, ln 30-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Kato et al with Aldinger et al's method of making a buffer layer for GaN because it is simpler and economically advantageous (col 1, ln 25-40).

Referring to claim 16, the nitriding process taught by the combination of Kato et al and Aldinger et al or the combination of Kato et al and Puchinger et al inherently forms an AlN layer on the sapphire substrate, which has a lattice constant between the sapphire and GaN

10. Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (EP 0999640 A2) in view Yuri et al (US 6,030,886) and further in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Sverdlov et al (US 5,888,886).

The combination of Nakamura et al, Yuri and Puchinger et al or the combination of Nakamura et al, Yuri and Aldinger et al teaches all of the limitations of claim 25, as discussed previously, except the epitaxial III-V nitride alloy film is grown by a sequential combination of

two or more different growth methods selected from the group consisting of metal organic chemical vapor deposition, molecular beam epitaxy and hydride vapor phase epitaxy.

In a method of making a III-V semiconductor, Sverdlov et al teaches Group III nitride compound semiconductor materials are promising material for light emitting devices and various techniques are known for growing Group III nitride semiconductors such as metalorganic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE) and the hydride vapor phase epitaxy method (HVPE) (col 1, ln 1-35), this a teaching of equivalent methods for growing Group III nitrides. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nakamura et al, Yuri and Puchinger et al or the combination of Nakamura et al, Yuri and Aldinger et al by growing group III nitride by a sequential combination of two or more different growth methods because MOCVD, MBE and HVPE are taught to equivalent methods of growing group III nitrides by Sverdlov et al and the combination of equivalents for the same purpose is held to be obvious (MPEP 2144.06).

11. Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kato et al (US 6,423,984) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Sverdlov et al (US 5,888,886).

The combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al teaches all of the limitations of claim 25, as discussed previously, except the epitaxial III-V nitride alloy film is grown by a sequential combination of two or more different

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growth methods selected from the group consisting of metal organic chemical vapor deposition, molecular beam epitaxy and hydride vapor phase epitaxy.

In a method of making a III-V semiconductor, Sverdlov et al teaches Group III nitride compound semiconductor materials are promising material for light emitting devices and various techniques are known for growing Group III nitride semiconductors such as metalorganic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE) and the hydride vapor phase epitaxy method (HVPE) (col 1, ln 1-35), this a teaching of equivalent methods for growing Group III nitrides. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al by growing group III nitride by a sequential combination of two or more different growth methods because MOCVD, MBE and HVPE are taught to equivalent methods of growing group III nitrides by Sverdlov et al and the combination of equivalents for the same purpose is held to be obvious (MPEP 2144.06).

12. Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kawazu et al (US 5,764,673) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Sverdlov et al (US 5,888,886).

The combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al teaches all of the limitations of claim 25, as discussed previously, except the epitaxial III-V nitride alloy film is grown by a sequential combination of two or more different

growth methods selected from the group consisting of metal organic chemical vapor deposition, molecular beam epitaxy and hydride vapor phase epitaxy.

In a method of making a III-V semiconductor, Sverdlov et al teaches Group III nitride compound semiconductor materials are promising material for light emitting devices and various techniques are known for growing Group III nitride semiconductors such as metalorganic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE) and the hydride vapor phase epitaxy method (HVPE) (col 1, ln 1-35), this a teaching of equivalent methods for growing Group III nitrides. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al by growing group III nitride by a sequential combination of two or more different growth methods because MOCVD, MBE and HVPE are taught to equivalent methods of growing group III nitrides by Sverdlov et al and the combination of equivalents for the same purpose is held to be obvious (MPEP 2144.06).

13. Claims 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kato et al (US 6,423,984) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Furukawa et al (US 6,017,807)

The combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al teaches all of the limitations of claim 23, as discussed previously, except the epitaxial III-V nitride alloy film comprises a pn junction.

Furukawa et al discloses a GaN compound semiconductor made up of a plurality of p-type, n-type or I-type GaN compound semiconductors, which are formed by MOCVD or MBE on a sapphire substrate. Furukawa et al also discloses a PN junction type consisting of a buffer layer which is made of a GaN layer formed on a sapphire substrate and a laminated structure which is made up of an n-type GaN and a p-type GaN layer both being formed on the buffer layer. Furukawa et al also teaches a GaN compound semiconductor represented by the general expression $\text{Al}(x)\text{In}(y)\text{Ga}(1-x-y)\text{N}$ ($1 \geq x \geq 0$, $1 \geq y \geq 0$) (col 1, ln 15-35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al by doping the group III nitride to form a pn junction, as taught by Furukawa et al, because PN junctions are useful are blue light emitting diodes (col 1, ln 25-30).

14. Claims 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kawazu et al (US 5,764,673) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Furukawa et al (US 6,017,807)

The combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al teaches all of the limitations of claim 23, as discussed previously, except the epitaxial III-V nitride alloy film comprises a pn junction.

Furukawa et al discloses a GaN compound semiconductor made up of a plurality of p-type, n-type or I-type GaN compound semiconductors, which are formed by MOCVD or MBE on a sapphire substrate. Furukawa et al also discloses a PN junction type consisting of a buffer

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layer which is made of a GaN layer formed on a sapphire substrate and a laminated structure which is made up of an n-type GaN and a p-type GaN layer both being formed on the buffer layer. Furukawa et al also teaches a GaN compound semiconductor represented by the general expression $\text{Al}(x)\text{In}(y)\text{Ga}(1-x-y)\text{N}$ ($1 \geq x \geq 0$, $1 \geq y \geq 0$) (col 1, ln 15-35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al by doping the group III nitride to form a pn junction, as taught by Furukawa et al, because PN junctions are useful are blue light emitting diodes (col 1, ln 25-30).

15. Claims 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (EP 0999640 A2) in view Yuri et al (US 6,030,886) and further in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Furukawa et al (US 6,017,807)

The combination of Nakamura et al, Yuri et al and Puchinger et al or the combination of Nakamura et al, Yuri et al and Aldinger et al teaches all of the limitations of claim 23, as discussed previously, except the epitaxial III-V nitride alloy film comprises a pn junction.

Furukawa et al discloses a GaN compound semiconductor made up of a plurality of p-type, n-type or I-type GaN compound semiconductors, which are formed by MOCVD or MBE on a sapphire substrate. Furukawa et al also discloses a PN junction type consisting of a buffer layer which is made of a GaN layer formed on a sapphire substrate and a laminated structure which is made up of an n-type GaN and a p-type GaN layer both being formed on the buffer layer. Furukawa et al also teaches a GaN compound semiconductor represented by the general

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expression $\text{Al}(x)\text{In}(y)\text{Ga}(1-x-y)\text{N}$ ($1 \geq x \geq 0$, $1 \geq y \geq 0$) (col 1, ln 15-35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nakamura et al, Yuri et al and Puchinger et al or the combination of Nakamura et al, Yuri et al and Aldinger et al by doping the group III nitride to form a pn junction, as taught by Furukawa et al, because PN junctions are useful are blue light emitting diodes (col 1, ln 25-30).

16. Claim 20 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kawazu et al (US 5,764,673) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Iaconi et al (US 6,048,790).

The combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al teaches all of the limitation of claim 20 including a gas atmosphere of ammonia, which is a well known reducing gas (Narumi et al below), as discussed previously, except the gas atmosphere comprises radical nitrogen atoms.

In a deposition of a thin film using a reducing ambient, Iaconi et al teaches a reducing ambient of hydrogen gas, nitrogen gas or reactive nitrogen such as plasma, i.e. radical nitrogen atoms (col 5, ln 1-65). Iaconi et al also teaches a reactive nitrogen plasma may be sufficiently reducing without heating of the substrate (col 5, ln 15-30). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kawazu et al and Puchinger et al or the combination of Kawazu et al and Aldinger et al because radical nitrogen is a known equivalent to a reducing gas and substitution of a known equivalent

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for the same purpose is obvious (MPEP 2144.06) and a reducing ambient can be produced without heating, which reduces operating costs.

17. Claim 20 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kato et al (US 6,423,984) in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Iacononi et al (US 6,048,790).

The combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al teaches all of the limitation of claim 20 including a gas atmosphere of ammonia, which is a well known reducing gas (Narumi et al below), as discussed previously, except the gas atmosphere comprises radical nitrogen atoms.

In a deposition of a thin film using a reducing ambient, Iacononi et al teaches a reducing ambient of hydrogen gas, nitrogen gas or reactive nitrogen such as plasma, i.e. radical nitrogen atoms (col 5, ln 1-65). Iacononi et al also teaches a reactive nitrogen plasma may be sufficiently reducing without heating of the substrate (col 5, ln 15-30). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Kato et al and Puchinger et al or the combination of Kato et al and Aldinger et al because radical nitrogen is a known equivalent to a reducing gas and substitution of a known equivalent for the same purpose is obvious (MPEP 2144.06) and a reducing ambient can be produced without heating, which reduces operating costs.

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18. Claim 20 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (EP 0999640 A2) in view Yuri et al (US 6,030,886) and further in view of Puchinger et al (Gallium nitride thin layers via a liquid precursor route) or Aldinger et al (US 6,254,675) as applied to claims 16, 17, 19, and 24 above, and further in view of Iacoponi et al (US 6,048,790).

The combination of Nakamura et al, Yuri et al and Puchinger et al or the combination of Nakamura et al, Yuri et al and Aldinger et al teaches all of the limitation of claim 20 including a gas atmosphere of ammonia, which is a well known reducing gas (Narumi et al below), as discussed previously, except the gas atmosphere comprises radical nitrogen atoms.

In a deposition of a thin film using a reducing ambient, Iacoponi et al teaches a reducing ambient of hydrogen gas, nitrogen gas or reactive nitrogen such as plasma, i.e. radical nitrogen atoms (col 5, ln 1-65). Iacoponi et al also teaches a reactive nitrogen plasma may be sufficiently reducing without heating of the substrate (col 5, ln 15-30). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nakamura et al, Yuri et al and Puchinger et al or the combination of Nakamura et al, Yuri et al and Aldinger et al because radical nitrogen is a known equivalent to a reducing gas and substitution of a known equivalent for the same purpose is obvious (MPEP 2144.06) and a reducing ambient can be produced without heating, which reduces operating costs.

19. Claim 34-35, 37-40, 42, 48 and 51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nanishi et al (JP 11-243229), where US 6,146,916 is used as an accurate translation, in view of Ito et al (US 5,699,035).

Nanishi et al teaches a method of forming a GaN based semiconductor layer includes the steps of forming a ZnO buffer layer on a glass or silicon substrate and epitaxially growing a GaN based semiconductor layer on the ZnO buffer layer ('916 Abstract). Nanishi et al also teaches the ZnO buffer layer is polycrystalline ('916 col 5, ln 20-25). Nanishi et al also teaches the epitaxial layer is deposited using electron cyclotron resonance-molecular beam epitaxy ('916 claim 1).

Nanishi et al does not disclose spreading a liquid comprising a metal element and oxygen on a substrate and forming a spin coated layer of the liquid on the substrate by spinning at selected rotation speeds and annealing so as to crystallize the spin coated layer.

In a method of forming a ZnO thin film, note entire reference, Ito et al teaches a conventional spin coating, where an eyedropper is used to deposit a precursor solution with excess liquid being removed through the rotation yielding a solid metal oxide layer on to a silicon substrate or sapphire substrate (col 5, ln 1-40 and col 3, ln 40-60). Ito et al also teaches a precursor solution of metal alkoxides i.e. a liquid comprising metal and oxygen (col 4, ln 20-65). Ito et al also teaches annealing a metal oxide residue in an oxygen environment at 400-1000°C (col 5, ln 45-67 and Example 4). Ito et al also teaches ZnO layer with a grain size of less than 300 nm (col 2, ln 1-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Nanishi et al vapor phase growth with Ito et al's method of forming a crystalline film using solution because solution routes to single crystal thin films are economically advantageous, note Aldinger et al (col 1, ln 25-30), Puchinger et al (pg 154) and Lange, below.

Referring to claim 35 and 38, the combination of Nanishi et al and Ito et al teaches annealing a ZnO layer in oxygen prior to forming additional layers.

Referring to claim 37, the combination of Nanishi et al and Ito et al teaches an oxygen environment. The combination of Nanishi et al and Ito et al does not teach a H_2O gas atmosphere. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al by using a H_2O atmosphere because H_2O is a known equivalent to oxygen as a oxygen environment and substitution of a known equivalent for the same purpose is obvious (MPEP 2144.06)

Referring to claim 39-40, the combination of Nanishi et al and Ito et al teaches from a zinc oxide layer on a Si substrate. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al by using other known substrates, such as sapphire, SiC, GaAs, InP, GaP, ZnO, MgO, LiGaO₂, and LiAlO₂ because substitution of known equivalent is held to be obvious (MPEP 2144.06).

Referring to claim 42, the combination of Nanishi et al and Ito et al teaches a MBE process.

Referring to claim 48, the combination of Nanishi et al and Ito et al teaches annealing at 400-1000°C. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 51, the combination of Nanishi et al and Ito et al teaches annealing in an oxygen environment.

20. Claim 41 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nanishi et al (JP 11-243229), where US 6,146,916 is used as an accurate translation, in view of Ito et al (US 5,699,035) as applied to claims 34-35, 37-40, 42, 48 and 51 above, and further in view of

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Furushima (US 5,815,520) or Kitagawa et al (JP 04-068579), an English Abstract has been provided.

The combination of Nanishi et al and Ito et al teaches all of the limitations of claim 41, as discussed previously, except the epitaxial nitride alloy film comprises a pn junction.

In a method of making a light emitting device, Furushima discloses a ZnO epitaxial layer buffer layer 2 on a sapphire 1 or silicon 9 substrate and a InGaAlN buffer layer 3 and an n-type InGaAlN cladding layer 4 grown on the ZnO layer, where the layers are formed by MOCVD, metal organic chemical vapor deposition, to form a pn junction, note entire reference. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al by forming a pn junction, as taught by Furushima to make a useful light emitting diode.

In a method of making a light emitting diode, Kitagawa et al teaches a ZnO layer and an n-type GaN and p-type GaN layer formed, thereon to form a GaN pn junction light emitting element (Abstract). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al with Kitagawa et al's pn junction to forming a useful light emitting element.

21. Claim 37 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nanishi et al (JP 11-243229), where US 6,146,916 is used as an accurate translation, in view of Ito et al (US 5,699,035) as applied to claims 34-35, 37-40, 42, 48 and 51 above, and further in view of Hofmann et al (US 4,784,975).

The combination of Nanishi et al and Ito et al teaches all of the limitations of claim 37, as discussed previously, except the atmosphere comprises H₂O.

In a method of annealing, note entire reference, Hofmann et al teaches annealing in an ambient that contains an oxygen containing gaseous species, where suitable oxygen containing species include oxygen and H₂O (col 3, ln 50-67). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al because H₂O is a known equivalent to oxygen as an oxygen atmosphere and substitution of a known equivalent for the same purpose is obvious (MPEP 2144.06).

22. Claim 43 is rejected under 35 U.S.C. 103(a) as being unpatentable over Nanishi et al (JP 11-243229), where US 6,146,916 is used as an accurate translation, in view of Ito et al (US 5,699,035) as applied to claims 34-35, 37-40, 42, 48 and 51 above, and further in view of Sverdlov et al (US 5,888,886).

The combination of Nanishi et al and Ito et al teaches all of the limitations of claim 43, as discussed previously, except the epitaxial III-V nitride alloy film is grown by a sequential combination of two or more different growth methods selected from the group consisting of metal organic chemical vapor deposition, molecular beam epitaxy and hydride vapor phase epitaxy.

In a method of making a III-V semiconductor, Sverdlov et al teaches Group III nitride compound semiconductor materials are promising material for light emitting devices and various techniques are known for growing Group III nitride semiconductors such as metalorganic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE) and the hydride vapor

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phase epitaxy method (HVPE) (col 1, ln 1-35), this a teaching of equivalent methods for growing Group III nitrides. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Nanishi et al and Ito et al by growing group III nitride by a sequential combination of two or more different growth methods because MOCVD, MBE and HVPE are taught to be equivalent methods of growing group III nitrides by Sverdlov et al and the combination of equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Response to Arguments

23. Applicant's arguments, see page 8-9 of the remarks, filed 12/2/2004, with respect to the rejection(s) of claim(s) 16 under Nakamura in view Puchinger or Aldinger have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Kawazu et al (US 5,764,673), Yuri et al (US 6,030,886), Kato et al (US 6,423,984), Puchinger and Aldinger.

24. Applicant's arguments with respect to claims 16-17, 19-20, 23-25, 31-33, and 52-55 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

25. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

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Maruska et al (US 6,284,395) teaches nitriding a sapphire substrate forms AlN, which promotes the growth of nitride films (col 6, ln 20-65).

Ciszek (US 5,785,769) teaches the lattice constant for silicon is 5.43088 angstroms (col 4, ln 15-25).

26. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

27. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song
Examiner
Art Unit 1765

MJS
February 17, 2005

NADINE G. NORTON
SUPERVISORY PATENT EXAMINER

